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Feasibility of iodine contrast enhanced CT-scan during a 18F-fluorodeoxyglucose Positron Emission Tomography

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ABSTRACT: OBJECTIVE: this prospective study evaluates the feasibility in current clinical practice of contrast enhanced CT-scan for diagnosis purpose, performed during 18FDG PET-CT study with a PET/CT tomography. METHOD: 25 patients underwent FDG imaging for lymphoma staging. The PET scan was done immediately after the usual low dose CT (lCT). A second CT scan was consequently acquired, by using classical diagnosis CT parameters (dCT) and iodinated contrast. For each patient, all CT attenuation correction (CTAC) PET images were visually compared. Density in Hounsfield units (HU) and maximum Standardized Uptake Value (SUVmax) were then measured on different organs and up to 5 specific lymphoma localizations (total of 294 measurements). RESULTS: Visual analysis was similar for the 2 modalities, without discordant interpretation for the pathologic sites. SUVmax means and standard deviation of each organ for lCTAC and dCTAC were comparable. The equation of the fitted multiple linear regression model was: dCT=0.0748191 + 1.17024*lCT (98.71%; $p < 0.01$).CONCLUSION: These first results allow the use of injected CT scan, before the PET scan acquisition for lymphoma staging with this PET-CT scan, not affected by the height atomic number and elevated density. A great benefit is therefore obtained on diagnostic, logistic and radioprotection purposes.

KEYWORDS: Image reconstruction in medical imaging; Gamma camera, SPECT, PET PET/CT, coronary CT angiography (CTA); Multi-modality systems

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1 Introduction

Actually, both CT scan (computed tomography) and PET scan (positron emission tomography) are required in the staging and follow-up of Hodgkin and non-hodgkin lymphomas [1]. CT scan provides anatomic structures, and contrast enhanced CT shows vessels, lymph nodes, digestive structures with a better contrast, thus anatomical diagnosis is more precise. PET scan shows increased intracellular accumulation of 18F-FDG (18 fluorine deoxyglucose), thus providing functional information in terms of high metabolic activity in tumor sites. Contrast enhanced CT scan is usually performed in radiology units and PETscan in nuclear medicine units. Actually, most of the cameras are PET/CT cameras and a complete FDG study include a low dose, non injected CT scan, performed immediately before the PET acquisition, for attenuation correction of the 511 KeV gamma photons and for locating purpose. This system provides fusion imaging, with both functional parameters given by PET scan and anatomical information given by CT scan.

The aim of this prospective study is to evaluate the feasibility in current clinical practice of contrast enhanced CT-scan for diagnosis purpose, performed during 18FDG PET-CT study.

2 Method

25 patients (8 males and 17 females, mean age 46 ± 17 years), underwent 18F-FDG imaging for lymphoma staging (Hodgkin disease: 8, non Hodgkin lymphomas: 17).Standard activity was intravenously administrated one hour before PET examination (5.2 MBq/kg of 18F-FDG) and optimal condition for glycaemia was verified, (mean blood glucose level: $6.00 \pm 1,17$ mmoles/L) The camera we used was a GEMINI PET-CT camera PHILIPS MEDICAL SYSTEMS. Low dose for locating and for attenuation correction CT (lCT) was first realized with usual parameters (120 KeV — 100 mAs — slices 3.2 mm — FOV 600mm — free breathing). Then, 18F-FDG TEP examination with the same coverage was done immediately after the first lCT scan. A second full dose CT scan (dCT) with classical diagnosis purpose parameters (120 KeV — 270 to 350 mAs — slices 6 mm — FOV 600mm) and free breathing with iodinated contrast (100 ml of Iobitridol) was consequently

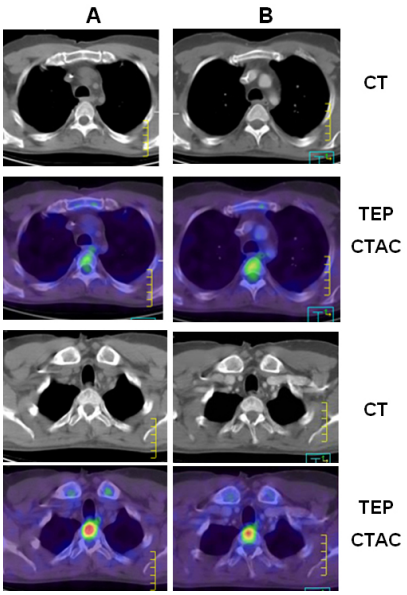

Figure 1. No difference for malignancy diagnosis on CTAC images corrected by lCT and dCT — upper: non metastatic vertebra — lower: metastatic vertebra A: non injected CT — B: injected CT

acquired just after the PET examination [2, 3]. Delay between injection and acquisition was around 45 seconds (venous phase). Dosimetric data were similar than that obtained with diagnosis purpose CT scan (mean DLP: 998.83 ± 359.96 mGy*cm Range 581.8–1501.5 mGy*cm).

Visual comparison, for each patient, on CTAC PET images, corrected by both lCT and dCT, was performed by 3 experimented observers (C.H., C.T., I.M.). Density in Hounsfield units (HU) on CT images and maximum Standardized Uptake Value (SUV max) on both CTAC PET images were measured by ROI method (regions of interest). Studied regions (number of points of measure: $N = 294$) were located on different organs: brain (grey matter, white matter), lung, aorta, paravertebral muscles, liver, spleen, acetabulum (cortical and medullar bone) and up to 5 specific localisations depending on the pathology (tumour tissue, lymph nodes...).

3 Results

Visual analysis gave the same results for the 2 modalities, without discordant interpretation for the pathologic sites (figure 1).

SUVmax means (M) and standard deviation (SD) of each organ for lCTAC and dCTAC PET images were comparable (table 1). Means for different localisations for each patient were also similar.

A statistical study (multiple linear regression) was performed for SUVmax values on lCT and dCT CTAC PET images. Significant relationship between the variables at the 99% confidence level was found.

The equation of the fitted multiple regression linear model was:

$$dCTSUVmax = 0.0748191 + 1.17024 * lCTSUVmax$$

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Table 1. Density in HU and SUVmax means and SD for some organs (G.M.: grey matter; C.B.: cortical bone) for lCTAC and dCTAC images. Aorta has a low density in HU on lCT images and high density on dCT images; on lCTAC and dCTAC PET images, no real change was observed for SUVmax.

	lung	G.M.	C.B.	aorta
HU mean				
lCT	-747	48	480	37
dCT	-720	79	498	176
SUVmax mean				
lCT	0.47	5.48	0.60	1.20
dCT	0.45	6.80	0.38	1.52
SUVmax SD				
lCT	0.18	2.19	0.36	0.27
dCT	0.18	2.99	0.33	0.25

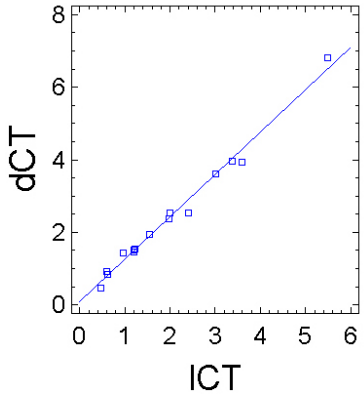

Figure 2. Statistic study: means for organs SUVmax — significant relationship between the variables at the 99% confidence level.

(with Adjusted R-squared statistic 98.712% $p < 0.01$) (figure 2). It means that for SUVmax there is only a regular increase of 17%, for all different absolute values. Relative values didn't change; this fact explains why no change was observed for visual analysis.

4 Discussion

Our results are in accordance with bibliographic data. Rodríguez-Vigil et al. [4] performed a prospective study of enhanced full-dose PET/CT versus unenhanced low-dose PET/CT during a PET/CT examination in lymphoma in 47 patients. They compare results on CTAC images corrected by injected CT (ICT) and non injected (NICT) on 24 lymph nodes regions and 8 extralymphatic sites. Less indeterminated data and more pathologic sites were seen with ICT, with a very good concordance for the staging. Their conclusion was that NICT is sufficient for the initial staging and ICT has to be reserved for special cases (i.e. dosimetric considerations).

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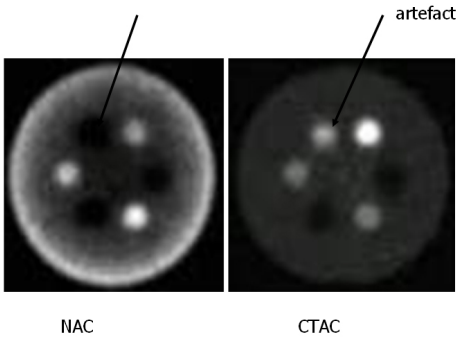

Figure 3. On CTAC image, false activity measured in the tube with KI solution without real activity inside; on NAC image, no activity is seen.

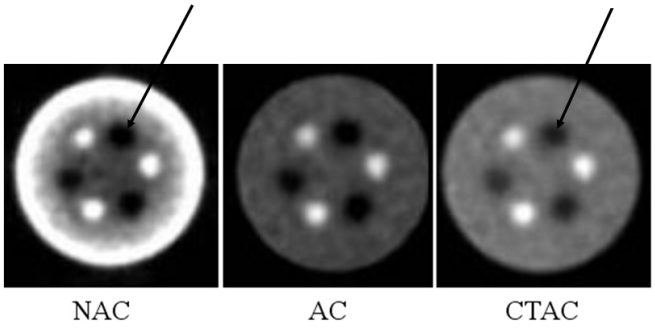

Figure 4. No artefact for the KI solution on CTAC image with our camera.

Yau YY et al. studied whether the application of intravenous contrast in PET/CT really introduces significant attenuation correction error [5]. Examinations were performed with a Discovery GE TEP-TDM on 54 patients, and 193 regions were compared, on CTAC images corrected by NICT et ICT (Visual analysis and SUVmax on both modalities). Their conclusion was that the correction by ICT doesn't increase significantly the SUVmax and visual analysis is not modified.

Similar studies have been already realized using other PET cameras [4–6], but important facts have to be verified. Phantom studies previously performed [7, 8], demonstrated that attenuation correction by CT for high atomic number may produce artefact, depending on the camera (3 types of PET/CT cameras have been experimented). This artefact consists in false activity measures in tube containing KI solution on the images corrected by CT (CTAC). These abnormal effects were not seen on the non corrected images (NAC) (figure 3). Enhanced CT scans are performed with iodinated contrast witch atomic number is 53. The camera we used was a Philips witch is not affected by high atomic number neither elevated density (figure 4). We could therefore demonstrate that there is no change for visual analysis and good statistical results for lCTSUVmax. and dCTSUVmax.

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5 Conclusion

These preliminary results allow the use of intravenously iodinated injected CT scan, before the PET scan acquisition with this PET-CT camera, for lymphoma staging.

A great benefit is therefore obtained on different purposes:

- diagnostic: better discrimination for lymph nodes and great vessels in mediastinum, better analysis of the digestive structures with the injected CT scan;
- logistic: the 2 examinations, PET scan and injected CT scan, are performed in one time and in the same unit;
- radioprotection: there is no need of low dose CT scan.

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